

NASA-TM-108019

NASA STI PROGRAM

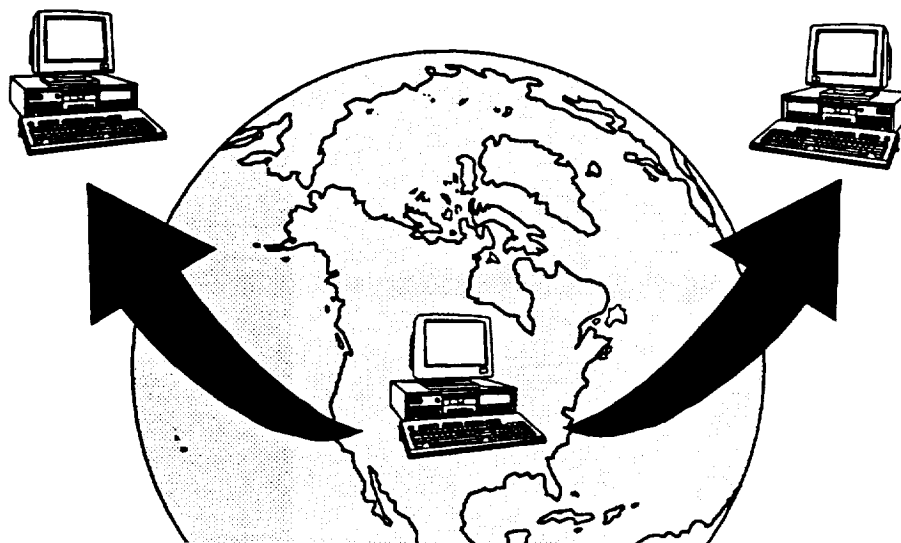
COORDINATING COUNCIL

Eighth Meeting JUNE 5, 1992

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P-52

Using the Internet



(NASA-TM-108019) COORDINATING
COUNCIL. EIGHTH MEETING: USING THE
INTERNET (NASA) 52 p

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SUMMARY

NASA STI Program Coordinating Council

Eighth Meeting

Using the Internet

June 5, 1992

Crystal City Gateway 2 Conference Room

Attendees:

JTT

Katie Bajis
Lisa Burdick
Jennifer Garland
Curtis Generous
Karen Holloway
Karen Kaye
Tom Lahr
Lucinda Leonard
Ann Normyle
Terese Ohnsorg
Lourdes Roy
Lou Ann Scanlan
Ron Sepic
Patt Sullivan
Ardeth Taber
Phil Thibideau
Dick Tuey
Kay Voglewede

JZ

Roland Ridgeway
Andy Schain

CASI

Wanda Colquitt
Faith Hardy
Joseph Judge
Stephen Mullen
Jean Tolzman
Chuck Walsh

AIAA/TIS

David Purdy

NSF

Dan Van Belleghem

USING THE INTERNET

STI LAN Migration

Because of the NASA STI Program Office move into the new NASA Headquarters (HQ) building and the contractors' move from the offices in Crystal Gateway II to new offices in Crystal Gateway IV (CGIV), new methods of electronic communication need to be established. Staff will need a LAN to communicate between and among remote sites and for access to Internet and NASA's two wide area networks, NASA Science Network (NSN) and the Program Support Communications Network Internet (PSCNI).

Network Operating System

The LAN uses a 3+ Network Operating System based on 10Base2 coaxial cable, also known as ThinEthernet. Modems are internal to the workstations and cannot be shared. Each workstation is attached to a T connector, all on the same cable. If you disconnect one workstation you risk bringing the whole network down.

ThinEthernet or 10Base2 technology means 10 megabits per second (mbps), baseband technology, with a maximum cable length of 200 meters. (ThickEthernet is 10Base5: 10 mbps, baseband, with a maximum cable segment length of 500 meters.)

Electronic Mail

Electronic mail is scheduled to change. Now there's 3+ Mail, a closed mail system on the LAN, a good interface with Macs and PCs. There's a dedicated phone circuit for it that connects to the server at Code JT at Headquarters. Then there is Quickmail. It's also a proprietary system but becomes open with a Simple Mail Transfer Protocol (SMTP) gateway. The Sun also uses SMTP open architecture. These three systems are connected through a multiport repeater, with 13 segments in all. There is also a connection to the NASA Headquarters Computer Center (NHCC).

At the new Headquarters building they use 10BaseT, or twisted pair, Ethernet for the LAN. The backbone tying the individual LANs together uses Fiber Digital Distributed Interface (FDDI), a fiber-optic-based, token-ring architecture that goes up to 100 mbps. There are only two analog data lines for JTT, with an ISDN-based phone system. However, many services are available over the Headquarters Network (HCN): NSN, PSCNI, NASAMail, and HCC.

Each workstation will have an RJ45 (six-wire) connector as its connection to the LAN. Each cable goes to a centralized concentrator that can track status and usage of each workstation. This technology is already in use at the NASA Center for AeroSpace Information (CASI).

Token ring technology is a third type of network; workstations are connected in a ring. When a packet of mail is sent, it travels around the ring, and each workstation accepts its own packet and sends the rest on.

Server Access

The offices at CGIV will continue to use 10Base2 technology; the cabling is already in place there. There will eventually be a connection to NSN, through which the CGIV staff can communicate with HQ-JTT and CASI. The procedures for exchanging files using a drop-off directory will change because the staff at CGIV will be using the Code JT server at HQ. Access to external servers will work differently. Quickmail will be discontinued. There will no longer be individual modems. The plan is to replace the 3+ service with Netware within 6 months. This is the Novell Network operating system now used at CASI; HQ will also be using it. You'll be able to access your files on the HQ, CGIV, or CASI server from any of the three locations and print at any of the three sites.

The three Netware networks will be interconnected using IP tunnelling. Each workstation will have its own TCP/IP server. Files will be able to be shared among PCs, Macs, and Sun workstations. The mail system will be cc:Mail (already in place at CASI), which has an SMTP gateway to Internet. ARIN/Systran systems will be accessible via NSN. Each workstation will not need to have a modem; Procom or Smartcom will use the modem on the server. Dial-in access will also be available. You'll be able to dial in from home and have access to the same services.

All PCs will be upgraded to 386s to run Windows; Macs will be upgraded to System 7.

Servers will have automatic backup to optical disk under the new configuration. Full Internet services will be available: the NASA Access Mechanism (NAM), Wide Area Information Servers (WAIS), ARCHIE, and NETNEWS. ARCHIE is a protocol that lets a user query in English to find a file on any machine on Internet.

Internet mail domain names may change from STI.NASA.GOV to STI.HQ.NASA.GOV. It is possible to set up a mail exchange (MX) to reroute your mail to the new domain so that you won't have to change your mail address on your business cards.

The ICCN Council is pushing for adherence to standards. The approved networking standard is Open Systems Interface (OSI), but the OSI service is not available yet. Until that time we can continue as we are under Approved Short Term Protocols (ASTP). Netware is moving toward OSI.

NSF and NREN

Don Van Belleghem, Assistant Program Director, National Science Foundation (NSF), discussed NSFNet and its relationship with the National Research and Education Network (NREN), NASA Science Internet (NSI), Energy Sciences Network, and so forth.

NSF has six supercomputing centers. They were started in 1984 and were running by 1987: at Princeton; the Cornell Supercomputing Center; one at NCSA at the University of Illinois; the Pittsburgh Supercomputing Center at Carnegie Mellon University; the San Diego Supercomputing Center; and a sixth at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Between 1986 and 1988 NSF joined all of these centers together with Internet Message Processors (IMPs), specially created for running TCP/IP. It was a 56 kilobit network.

At NSF, 50 percent of the computing and information science and engineering budgets go for infrastructure. Some funds come from high performance computing and communications (HPCC); NSFNet in turn supports math and physical sciences, geosciences, engineering, and behavioral and biological sciences.

A year ago NSFNet connected 1 million computers at more than a thousand institutions in all 50 states and in 30 countries. NSFNet will be the core of NREN.

NSFNet usage is growing at a rate of 11 percent a month, and is up to almost 15 billion packets a month. In less than a decade, since 1984, NSFNet's mission has shifted from giving chemists and astronomers

access to Cray supercomputers to helping to build the nation's communication infrastructure.

NSFNet incorporates more than 5,000 networks now, with 45 mbps, 16 links. Some lines were T-1 and are being converted to T-3, 45 mbit ones. RS/6000 switches or gateways from IBM are pushing the speed up from 10 mbps to 12 or more. Gateways are FTP, SMTP, and Telnet. SMTP has 21 percent, FTP has 29 percent, and Telnet has 14 percent. Sun uses the user datagram protocol (UDP), a dumb line that is easily replaced if one should go down, as opposed to TCP which connects and stands ready to send or receive. The network is more active than ARCHIE or WAIS, which are robots.

Information services means people at NSF: registration services, for instance. The Department of Defense (DoD) has cut back its services, so NSF has been paying their support contractor for the past year. NSF wants to enter into a cooperative agreement with an information services manager. The agreement will be for up to 5 years with \$2-4 million a year. They hope to make the award in late summer and have services available in late fall.

Architecture

The current architecture is hierarchical, from LANs on campuses or in buildings to a regional network that in turn connects to a nationwide backbone. NSF's funding is for local areas, such as campuses, to connect to a wider network and thence to the backbone, thus giving access to colleagues and information all over the country. Funding is generally on the order of \$20-25 thousand, with cost sharing from the local institution. Funding is working its way down from 4-year colleges to 2-year community colleges. Some people want to extend the network to K-12 schools, but NSF is a research organization and, besides, there are too many school districts to make serving them practical. With 1,400 colleges and 1,600 2-year colleges, the total is 3,000 colleges, and only a third of them are connected to the network to date.

NASA is connected to a network that reaches from Ames to Goddard and connects to Lawrence Livermore Laboratory and also to NSFNet: it's the Federal Internet Exchange. Using a Commercial Internet Exchange (CIX), commercial packets can thus go around NSFNet.

NREN

The National Research and Education Network (NREN) began in 1991.

Its implementation was planned in three stages with the first two being development. The goal of 45 mbps has been reached. There are testbeds and experiments going on. By 1995 they hope to reach 622 mbps, with 155 mbps as an interim stage.

NREN's object is to promote and enable research in astronomy, atmospheric sciences, biology, and other sciences that depend on supercomputers. It is not intended to be a vehicle for a child in Tennessee to connect to the Library of Congress to learn about dinosaurs. NREN is a multiple agency component of a high-performance computing initiative. NSF is playing a coordinating role. The Defense Advanced Research Projects Agency (DARPA) conducts the gigabit research.

Groups involved in NREN include the HPCC Committee and the HPCC Interagency Technical Group, the bureau at NSF for Computer and Information Science and Engineering (CISE), and the Federal Networking Council—all members of the Federal Committee for Computer Science, Engineering, and Technology (FCCSET). Memberships overlap. This overlap encourages all these organizations to share and not be proprietary once they have funding. The Federal Networking Council counts as members the General Services Administration (GSA), the National Oceanic and Atmospheric Administration (NOAA), the Department of Education, and the National Institute of Standards and Technology (NIST).

HRCC and the Office of Science and Technology Policy (OSTP) are encouraging privatization of NREN by allowing commercial service providers to interconnect with Federal research and education (R&E) networks. By so doing, NREN will eventually become more like a business, like the television industry.

The new architecture will have a network access provider connected by a 155 mbps backbone. There will be a network service provider and a routing arbiter who will select the best routes for packets to travel.

NSF is running NREN now as a service, but NREN is built with components from the private sector, and when NSF funding runs out NREN will be commercially operated. Organizations will have to pay to participate. NREN is general and for all of science and education; it

may be difficult to persuade individual discipline organizations to pay into it.

**The New NASA
Headquarters
LAN**

Andy Schain, Code JZ, described the new Headquarters LAN.

The move to the new NASA HQs building is proceeding successfully. There are 37 LANs at NASA HQs, plus subnets, running on five different operating systems. The new building is 550 feet long, 9 floors, with European standard 4-inch raised floors.

The LAN's backbone is FDDI. Each program office has its own router that touches the ring. The ring and all the routers are housed in the NASA Headquarters Computer Center (NHCC), along with IP addressing. In the future, additional rings can be deployed on other floors. Each floor has some 50 fibers available for future use.

The PSCN and NSI gateways are connected to routers via Ethernet. At a given time, the most expeditious route from a given location to one of these gateways can be used. For example, from Code J to get to PSCN, one can go through the Office of Space Flight's router and then Ethernet to the PSCN. To get to NSI, one could use a router in Code R or Code S.

Contractors are not located onsite in the new building, but still must have access to a LAN. Contractors connect via Ethernet to a router that then connects them to the specific program office they support. They can also access the LAN via Internet or PSCN.

Eventually PSCN will be phased out and NASA will use SMTP, then X.400 systems, and eventually X.500 directory over TCP/IP.

There is fiber throughout the new building, directly attached from each closet in the computer center in the basement; some are 50 count; the 10BaseT are 96 count. The Computer Center can track the traffic between codes and route it through the best server at the time, thus keeping the load balanced.

Access to the LACN and HCN is available. The library needs connectivity to LACN to get to ARIN and RECON. Different sets of

needs can be accommodated through NHCC. If someone needs access to the LAN plus two additional data lines, that setup can be patched right at the computer center. ST connectors for FDDI are housed in a box that sits by a person's desk; all other equipment is in the raised floor space. Data connectors and voice lines must not be confused. If someone plugs a modem into a voice jack it will burn up the modem board. The FTS 2000 connection is also housed in the basement. NHCC owns the cable and the closets, and thus will not have to rely on contractors to service them or to make changes.

The core net will begin with Codes J, H, G, and F and will add other codes later. It will consist of user accounts, authorization, and authentication, plus some storage: automatic backup and archiving. The principal application will be e-mail, including gateways. The user will log on to a file server located remotely in the basement, where there is room for 60 servers. Some file servers may eventually be located up on the floor with the users. Storage space will be allocated according to need as demonstrated by use. Backups will occur regularly. The core net will be based on ODS concentrators.

Storage and mail are the weak links in security. They will seem the same as they are now. Centralized storage will help keep the files secure. Disk space is sufficient for at least 2 years.

NASA Headquarters is the information hub for NASA. Raw data comes in from Congress and from other agencies and is turned into project information and disseminated to the rest of the agency. The networking facility in the new building will enhance this capability.

Videoconferencing should be available within 2 years.

The networking capabilities for Code JTT will be the same as before on moving day. Enhancements will follow.

Discussion

People at remote locations can access Internet through other gateways or other networks. For example, CASI has access to Internet through a link with NSN. The exact method will depend on the user's requirements and existing configuration.

CompuServe has a link for e-mail only; file transfer through CompuServe is possible only as e-mail attachments.

Eventually there may be video capability at CGIV, but for NASA Select only. There will be broadband capability there, and NASA Select is broadband.

Funding for NREN comes from four agencies: DARPA, NSF, NASA, and DOE. The chairperson of the NREN networking working group is Tony Villasenor from NASA.

There are no statistics as such on network use at NASA Headquarters, but traffic is monitored from NHCC. There are only three gateways to the outside world: PSCN, NSN, and the contractor connectivity links. The amount of bandwidth used can be monitored. Using 20 percent is fine; using 40 to 60 percent of available bandwidth can cause problems because there is no protocol for ThinNet and ThickNet technology. Carrier Sense Multiple Access/Collision Detection (CSMA/CD) doesn't work at all with too much traffic. Many people are using the Telnet protocol; e.g., anyone who talks to the Sun or anyone who talks to CASI via NSN. People are using SMTP for e-mail; a few people are using Network News Transfer Protocol (NNTP) for bulletin board service. Access is also available to the WAIS and to the ARCHIE server.

Next Meeting

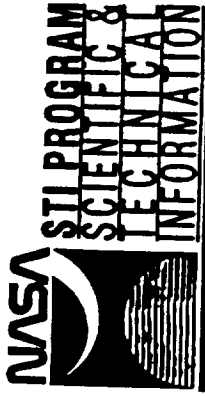
The next STI Program Coordinating Council meeting will be on October 28 in the Crystal Gateway IV conference room. The subject will be Total Quality Management (TQM).



STI LAN MIGRATION

(How will I spend my summer vacation)

Curtis Generous
June 5, 1992
generous@sti.nasa.gov



Current Situation

- **STI Organization Getting Split-up**
 - All Government People move to 300 Independence Avenue
 - All contractors move to Crystal Gateway IV - Suite 1200
- **Move Dates**
 - June 26 for Government
 - July 13 (tentative) for Contractors

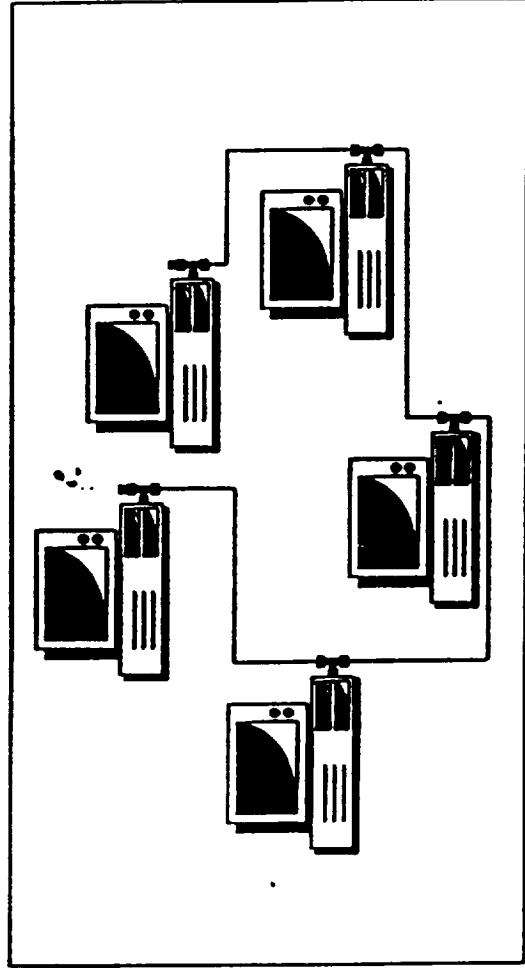
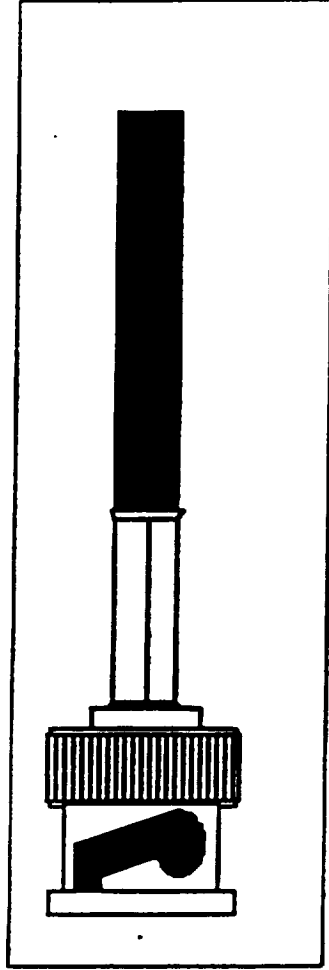
Current Topology

- **Uses 3+ (aka 3+Share) Network Operating System**
- **Cabling Plant based on 10Base2**
- **All Workstations Logically Attached to a Single Wire**
- **Many Internal / External Modems connected on Workstations**
- **Internet Routers also available on Local Cable (NSN and PSCNI)**
- **NHCC Connectivity via Dedicated 9600 baud Circuit**



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INFORMATION

10 Base 2 Ethernet



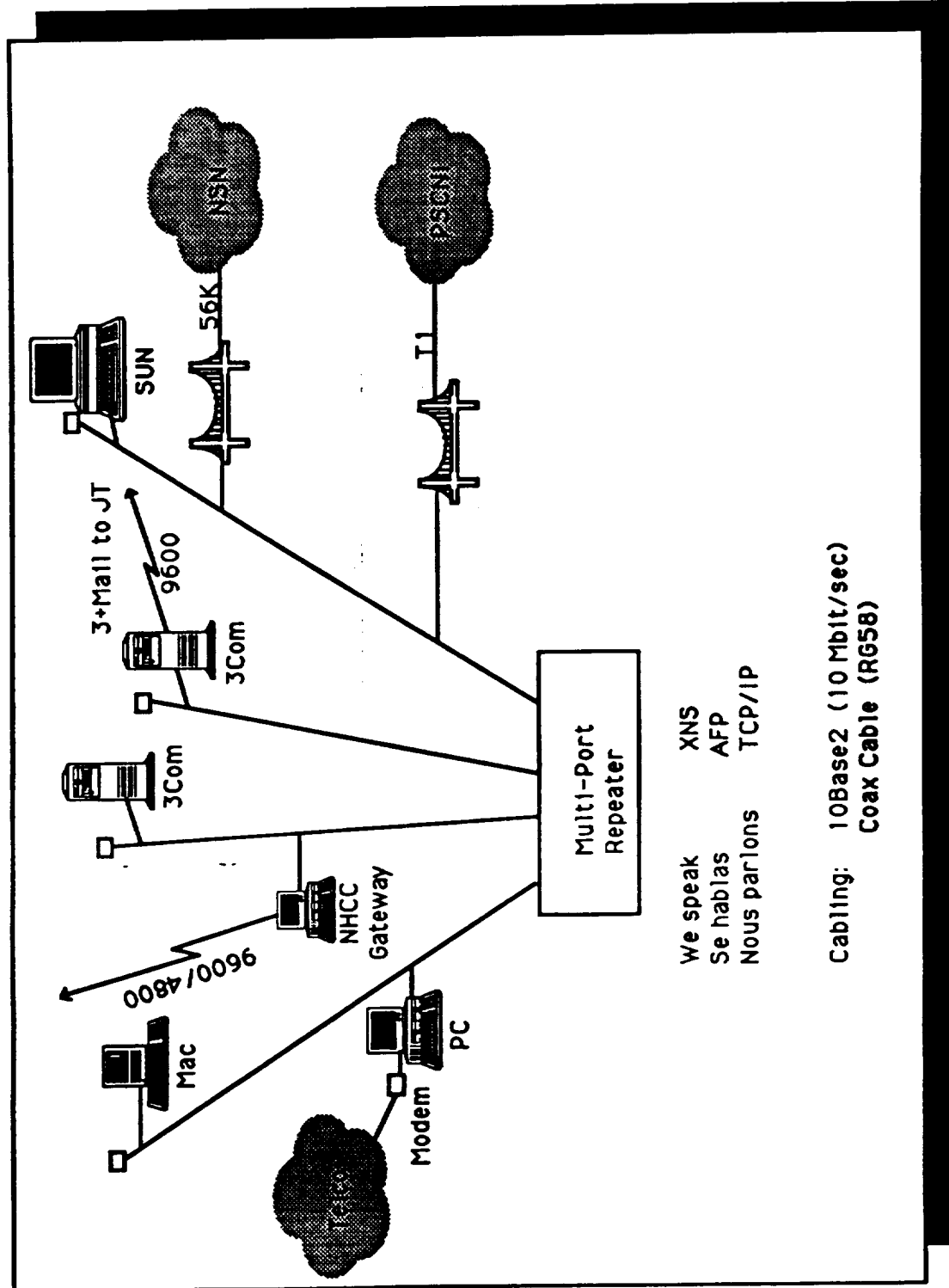
Current Email

- **3 + Mail**
 - Proprietary/Closed Architecture
 - Good UI on Mac's and PC's
 - Mail Routing to HQ over a Dedicated 9600 baud line
- **Quickmail**
 - Proprietary/Open via external SMTP gateway
 - Adequate PC/Mac interface
- **ELM**
 - SMTP/Open
 - User Interface via VT100 interface



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INFORMATION

Current LAN Map

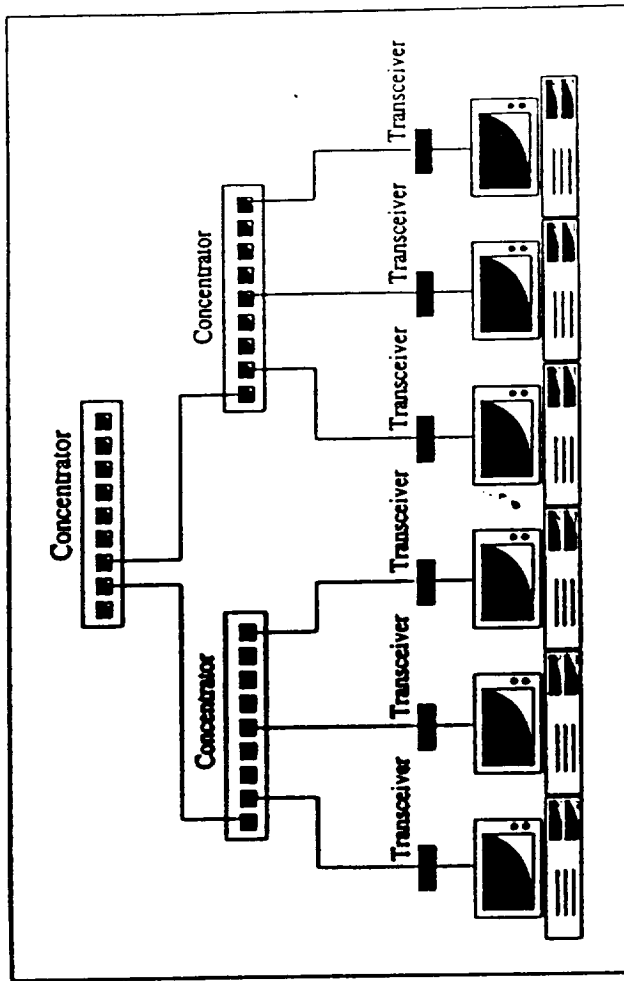
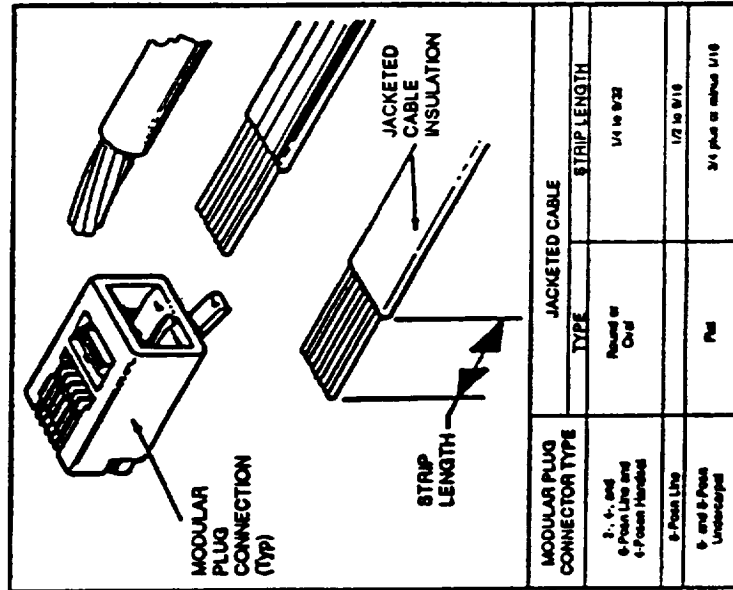




Future HQ-LAN Topology

- **LAN Cable Plant based on 10BaseT Cabling (10MPBS)**
- **Backbone Cable Plant based on FDDI (100MPBS)**
- **Very Limited Number of Analog Data Lines (2 for Code JTT)**
- **Phone System based on ISDN (i.e. no dial tone!)**
- **Many Network Services made available via the HCN**
 - NSN
 - NASAMail
 - PSCNI
 - NHCC

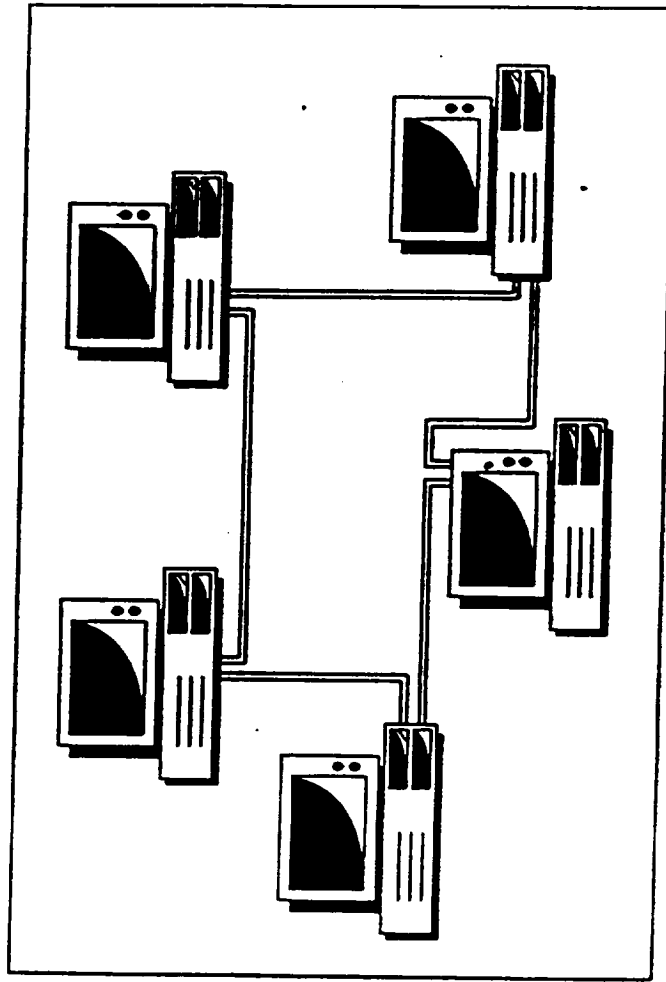
10 Base T





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Token Ring

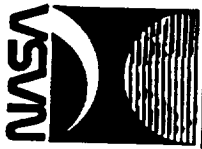




**STI PROGRAM
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INFORMATION**

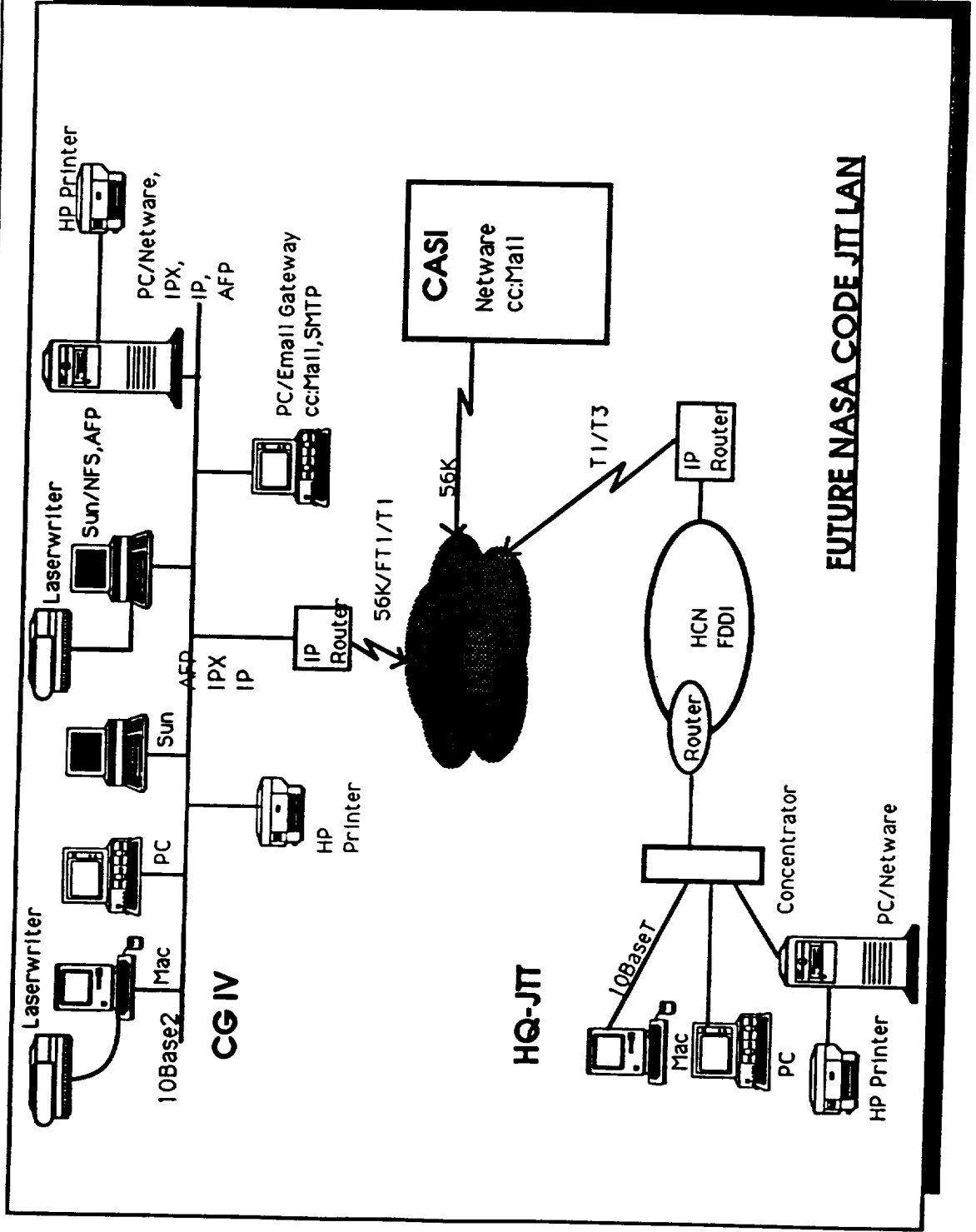
Future CG IV-LAN Topology

- **Cable Plant based on 10Base2**
- **T1 speed NSN Internet connection available from LAN**
- **PSCNI connection to be discontinued**
- **Cabling plant already in place**
- **NSN retermination paperwork well underway.**

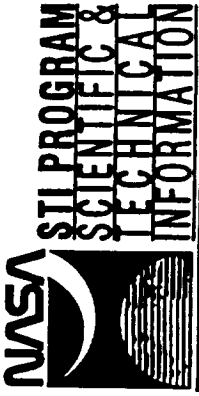


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Future LAN Map



FUTURE NASA CODE JTT LAN



Things to consider after the move...

- **Initially maintain 3+ NOS and 3+Mail system**
- **Folks in new HQ facility will share server with code JT**
- **Only Email services will be available between 2 sites.
(e.g. no common dropoff folder, no common printers,...)**
- **ARIN access no longer available via NHCC dedicated link**
- **Access to external services might work differently (e.g. Internet)**
- **Some local services will be discontinued (e.g. QuickMail, UNIX file sharing, no local modems, etc...)**

Planned Migration Strategy

- **Switch to Netware 3.11 NOS**
- **HQ, CGIV, and CASI will be configured as 3 interconnected
Netware networks.**
- **Use the NSN backbone to interconnect 3 Netware networks
(utilizing IP tunnelling)**
- **Servers will talk IPX, IP, and AFP protocols**
- **Native TCP/IP services at all Workstations!**
- **Shared file services provided by NetWare, AppleShare, and NFS.**



Planned Migration Strategycont

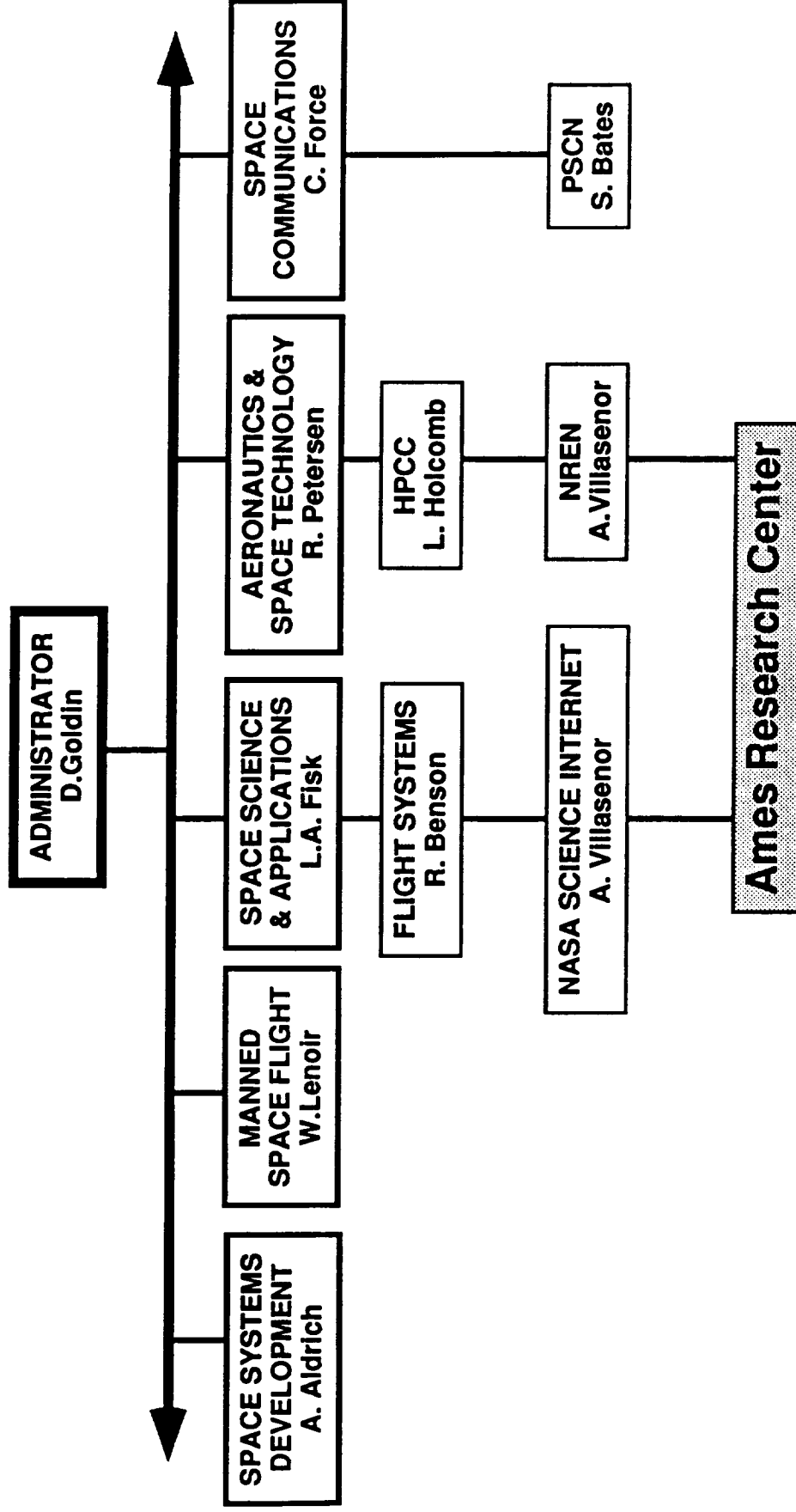
- Switch to new cc:Mail Email system, configured with SMTP gateways
- Use SMTP as common protocol between mail servers
- ARIN/Systran services provided over NSN via TN3270
- Provided shared/pooled modems to all workstations
- Upgrade PC's to Windows 3.x, Mac's to System 7.x
- Centralized backup services via optical read/write disk

Planned Migration Strategycont

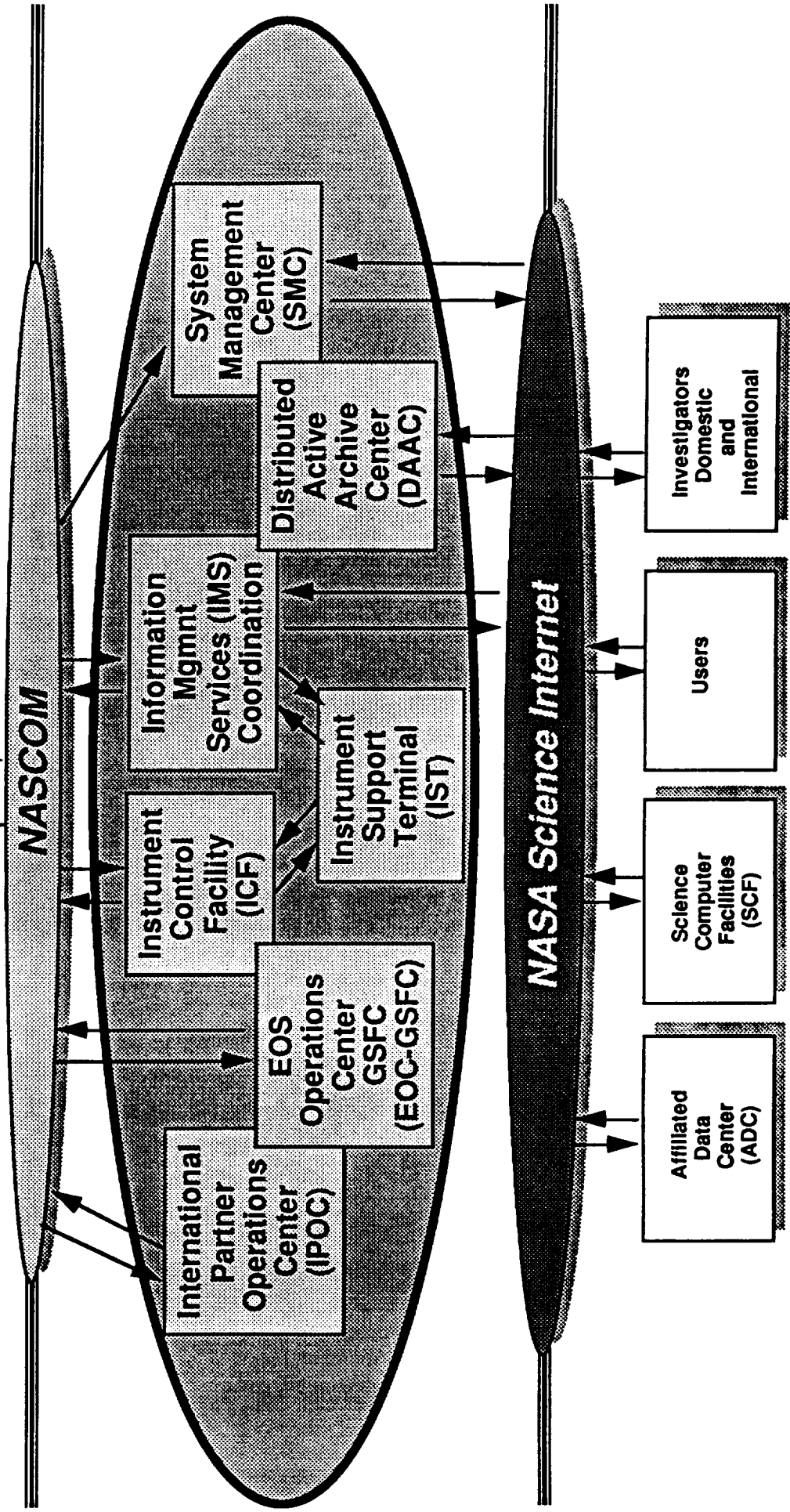
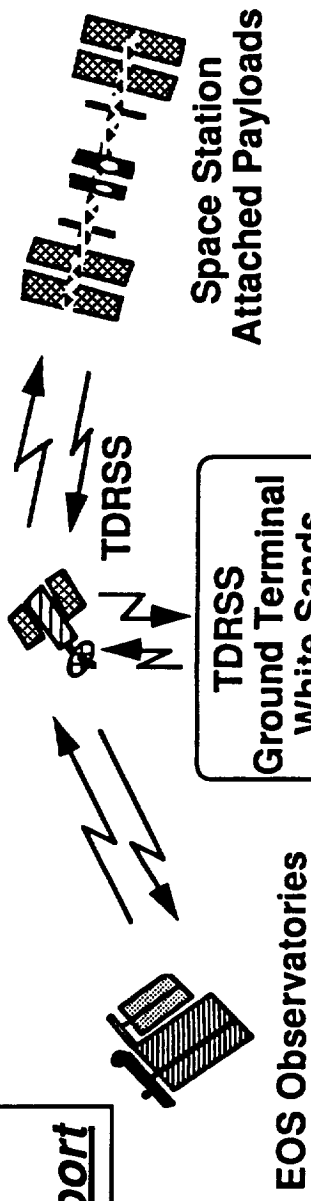
- **Full Internet Services provided (NAM, WAIS, ARCHIE, NETNEWS) at all workstations**
- **Workstation services supported include:**
 - telnet
 - X server
 - 'r' utilities
 - ftp
 - NFS
 - lpr printing
- **Provide dial-in capabilities to network services**
- **Network management tools using SNMP**



The NASA Organization

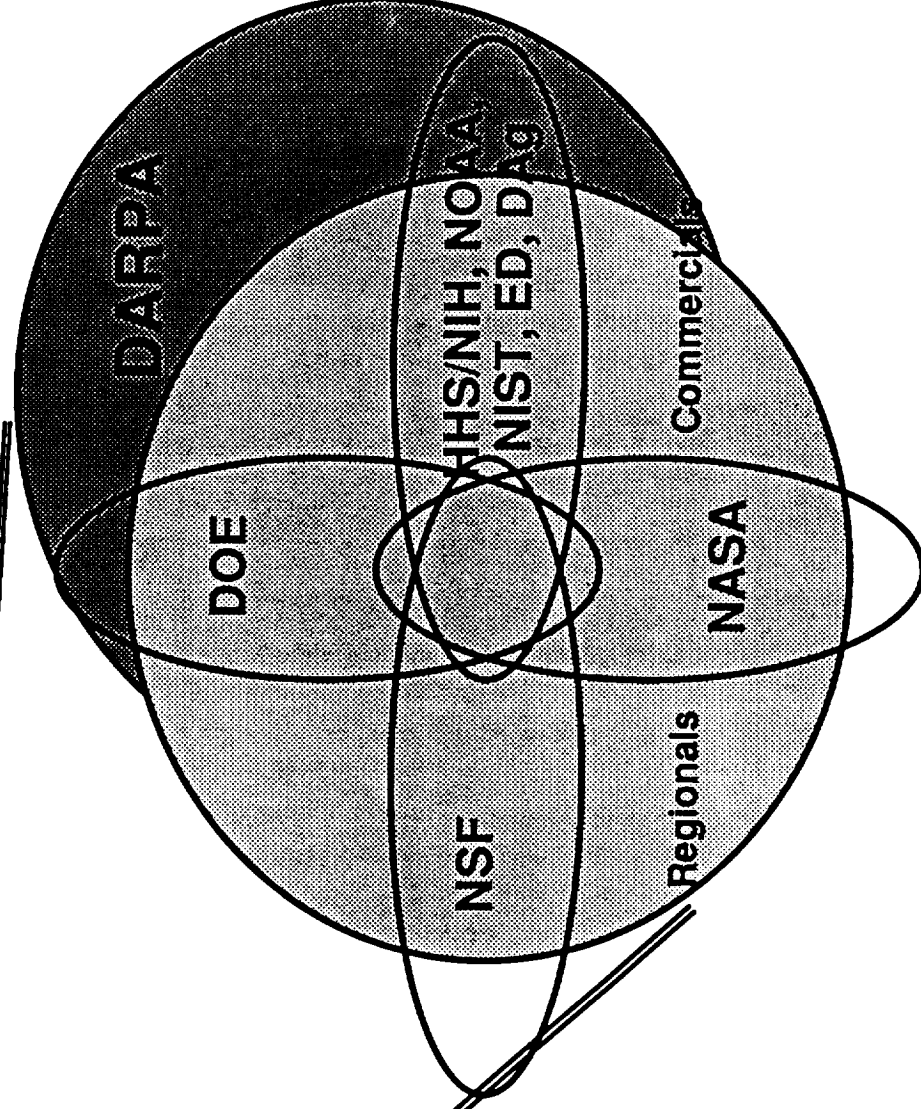


EOS
Mission Support

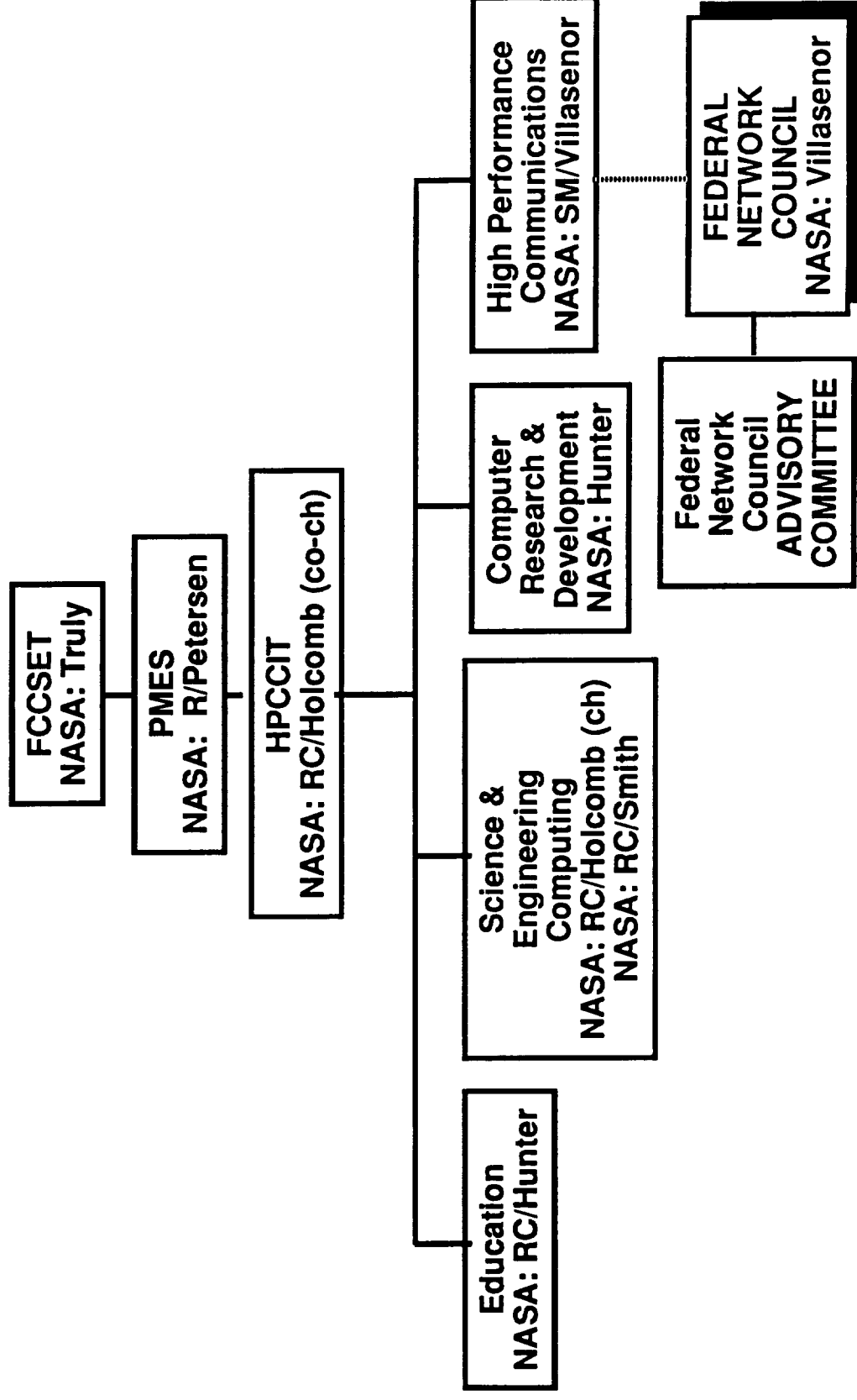


NREN Vision

OSTP
HPCC



HPCC Committees & NASA Membership

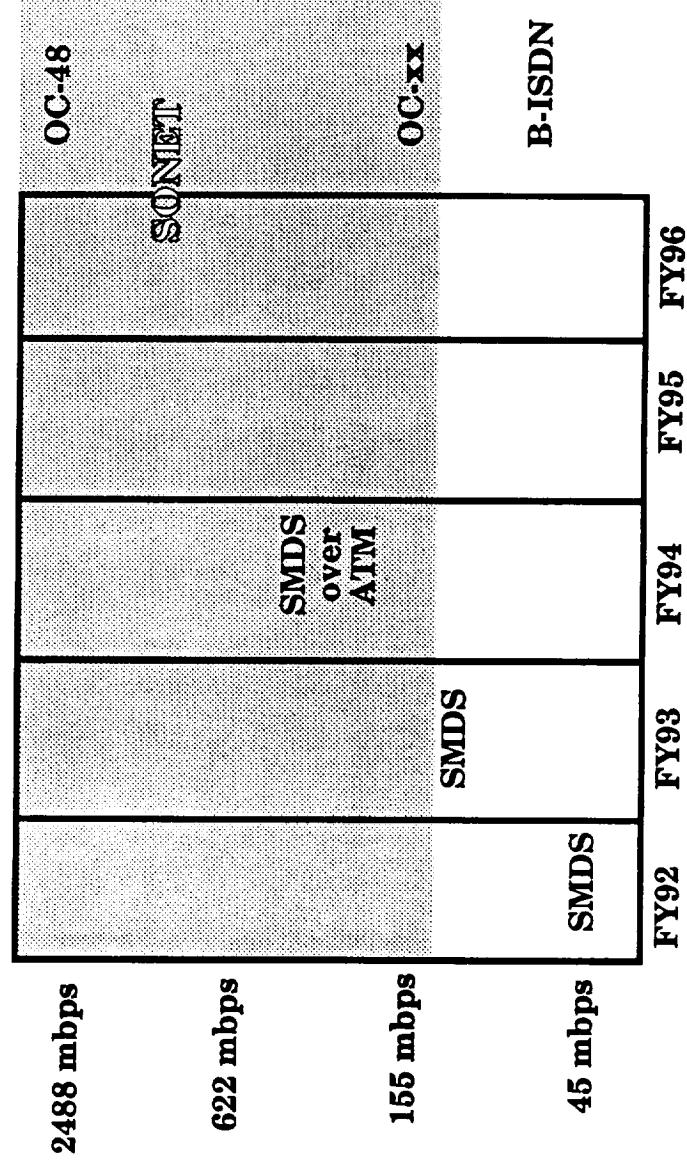


NREN: NASA Center Coordinators

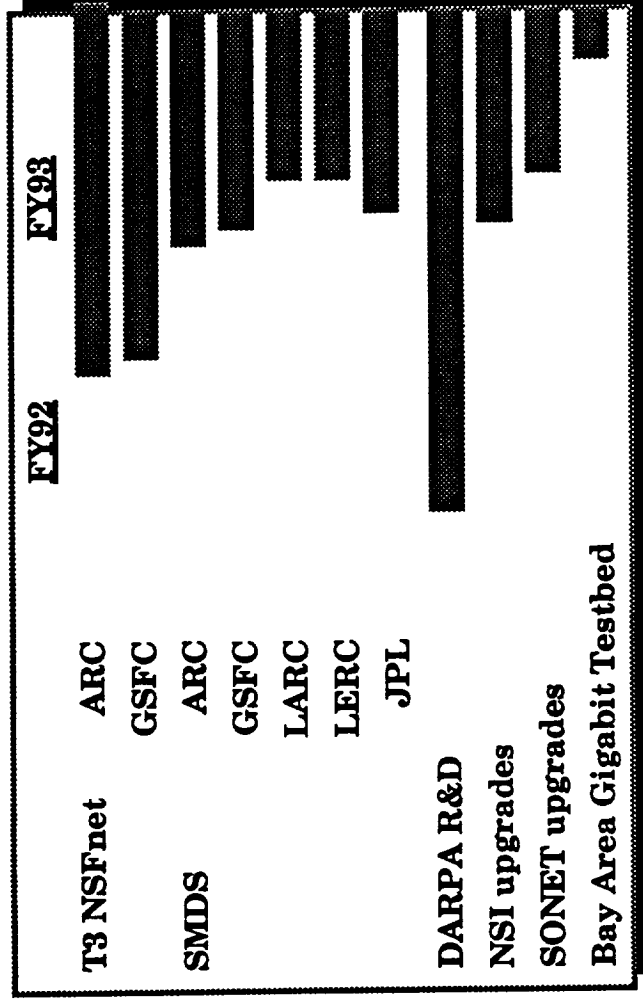
Intercenter Council for Computer Networking - Science

ICCN-S		
<u>CENTER</u>	<u>ORGANIZATION</u>	<u>RESPONSIBILITY</u>
ARC	Code ED	J. Yin
GSFC	Code 520	G. Dorman
JPL	Div. 37	D. Gallop
LARC	ACD	J.Nolan
LERC	MS 1390	D. Cica

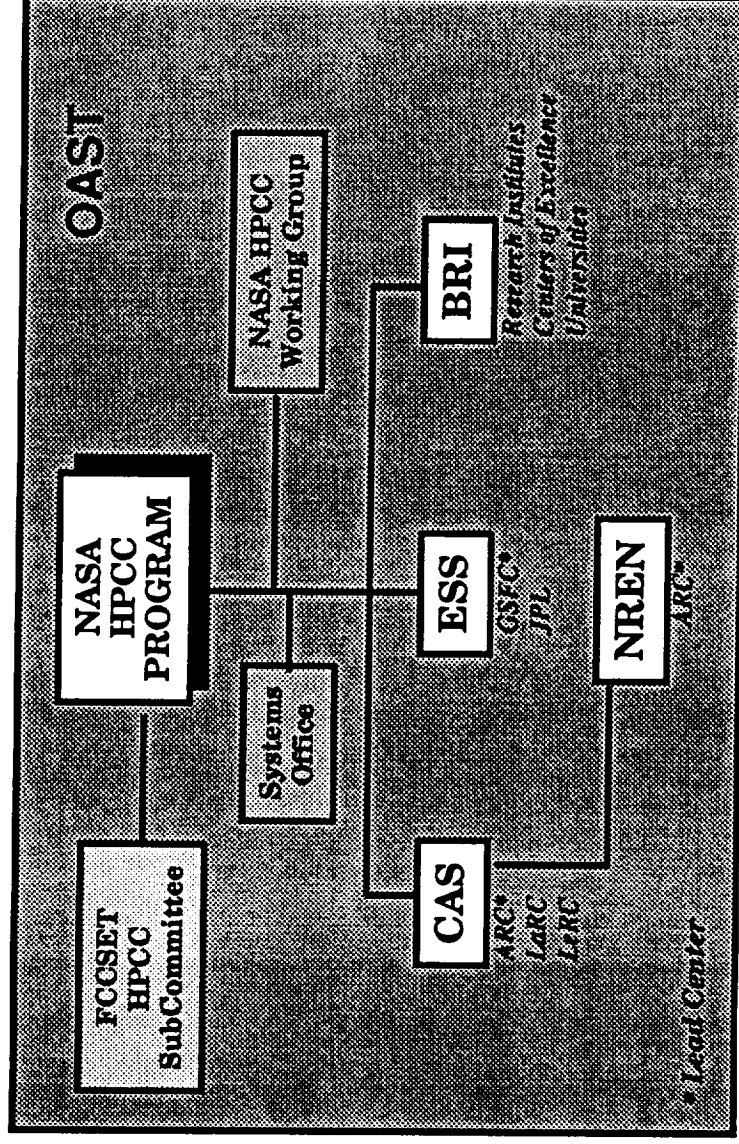
NASA & DOE Technology Migration Path



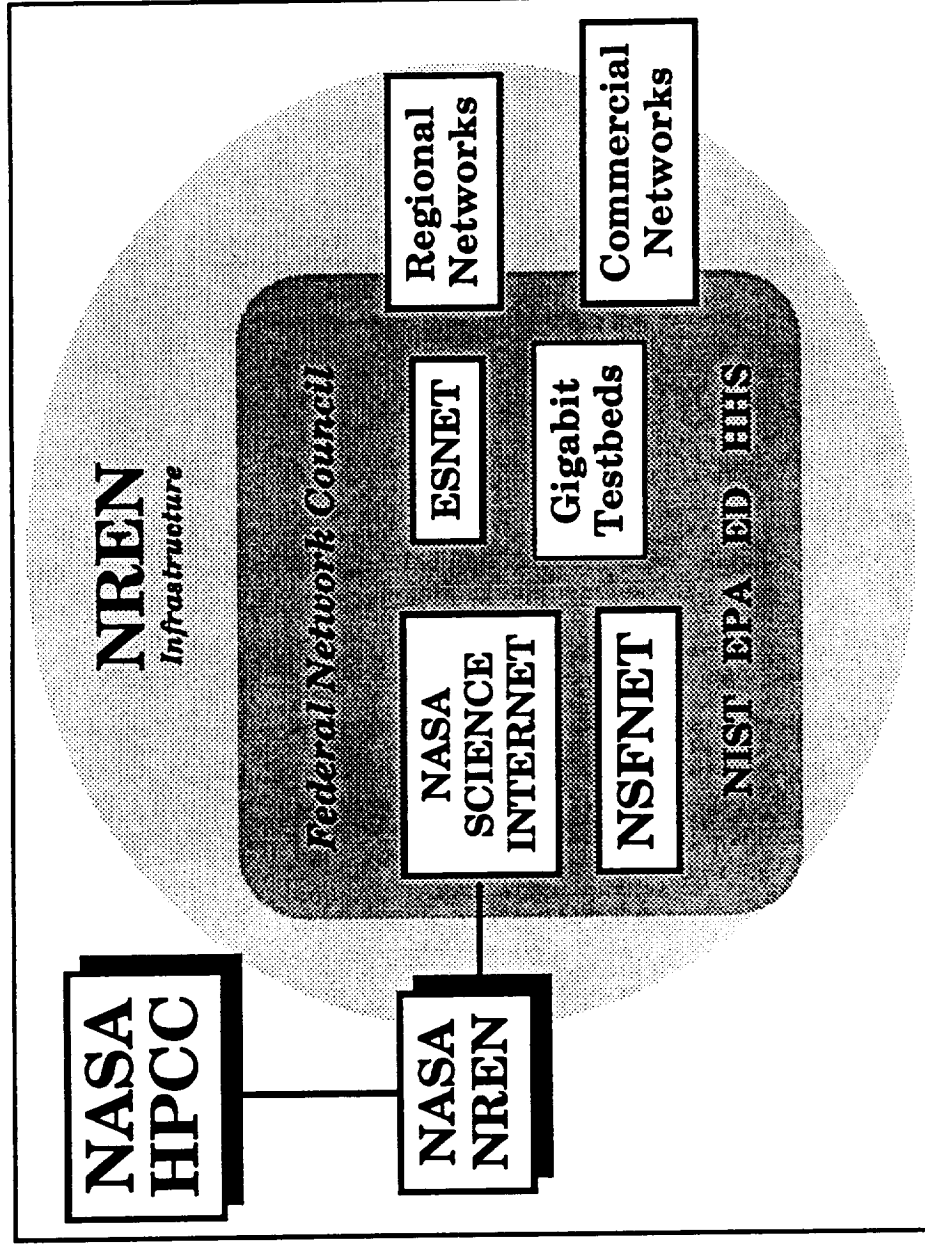
NASA/NREN Implementation Schedule



NASA HPCC Program Organization



NASA External Relationships



Tempering the Regionals

Regional Infrastructure Enhancements				
	FY92	FY93	FY94	FY95
MANAGEMENT & OPERATIONS				
Single point of control	▲			
24 x 7 operations staffing		▲		
Inter-NOC backup			▲	
ENGINEERING & TECHNOLOGY				
T1 to campus networks	▲			
T3 to campus networks			▲	
155 mbps access to NREN				▲
622 mbps access to NREN				▲
USER SERVICES				
NSFNET NIC	▲			
Applications: mail, X.500, etc.		▲		
NREN NIC			▲	
Advanced applications: multi-media				▲

NASA PERSPECTIVE

NASA'S NREN

- Funded by HPCC to provide investigator access to/between Grand Challenge facilities
- Represents less than 10% of overall NASA HPCC budget
- Primary role is to support HPCC!

REQUIREMENTS

- T3+ class service between 5 NASA HPCC Centers
- T1+ class service to ~100 Principal Investigators

NATIONAL CONTEXT

- NASA must coordinate NREN with other HPCC agencies
- NASA needs high performance national network infrastructure
- NASA supports U.S. science education and research

NASA Approach

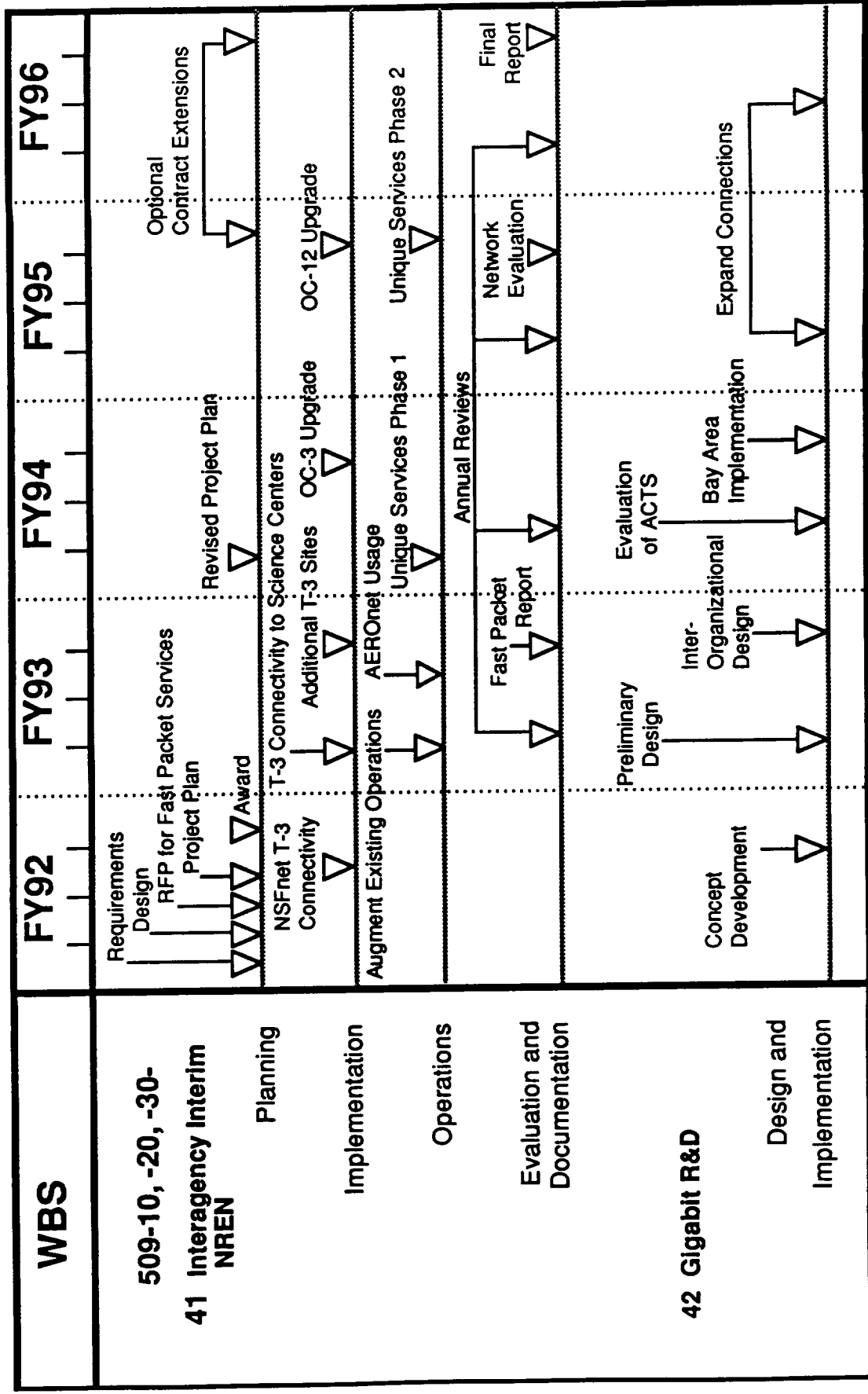
T3 SERVICE BETWEEN NASA CENTERS

- **Provided by SMDS switching fabric**
- **Used wherever high performance access is required**
- **Provides access to existing NASA networks with HPCC users**
- **Leverages on TELCO investments & directions**

T1 SERVICE TO NASA INVESTIGATORS

- **Assumes investigators at sites already connected (i.e., NSFNET)**
- **No NASA funds for point-to-point T1's**
- **Use T3 to NSFnet for aggregated T1 requirements**
- **NSFnet access via FIX's, after upgrade to FDDI**

NREN: LEVEL 2 MILESTONES



Current Telecommunications Infrastructure

DEDICATED POINT-TO-POINT LEASED LINES

- Local loop provided by Local Exchange Carriers (LEC's)
- Long haul provided by Inter-eXchange Carriers (IXC's)
- No customer switching equipment at TelCo central offices
- Possibility of link failure requires redundancy
- Dedicated to single user use (and billing!)
- Limited bandwidths available (9.6, 56, 1544 kbps, etc...)
- User must provide network monitoring and diagnostics (e.g., PSCN COMM)
- Routers at user sites perform packet switching
 - LAN interfaces (e.g., Ethernet, FDDI, etc.)
 - WAN interfaces (e.g., serial sync lines using V.35, etc.)
 - Switch packets from serial line to serial line or LAN
 - Provide network layer routing

Switched Multimegabit Data Service

SMDS (Bellcore specification)

- **Designed for 1.5 - 155 Mbps (extensible to 622 Mbps)**
- **Public addressing standard (E.164 - phone numbers!)**
- **Connectionless datagram protocol**
- **Neighbors can be configured as Virtual Private Net (VPN)**
- **Multicast supported inside the VPN**
- **Internally carried as 53 byte fixed length cells**
- **Available from some LEC's now at 1.5 Mbps**
- **Router interfaces more sophisticated (IEEE 802.6)**
- **Preferred by most LEC's and IXC's for service interface**
- **Requires SONET at 155 Mbps (STS-3c) and above**

Asynchronous Transfer Mode

ANSI T1S1 Group

- **Designed for use at 155 Mbps and above (requires SONET)**
- **53 byte cell transport**
- **Addressing, routing, accounting, congestion & flow control not well defined as yet**
- **Many possible user interface standards (including SMDS)**
- **Also suitable for high speed LAN architectures**
- **Long term goal for Telco internal substrate**

COST CONSIDERATIONS

POINT-TO-POINT LEASED LINES

- T3 price based on T1 price, T1 prices based on 56Kbps, etc.
- Strong price hierarchy to prevent reselling & undercutting supply carrier
- ARC-GSFC dedicated T3 cost = \$3 Million/year
- ARC-GSFC internal Telco cost significantly less!

SMDS APPROACH

- Prices based on access class (1.5, 4, 10, 16, 34.... Mbps)
- Telcos can trunk internal net using internal cost, since no reselling of leased circuits is possible
- Distance insensitive pricing
- Same switching fabric can support Frame Relay and low speed uses

SMDS Implementation Approach

- 1. Leverage on DOE/LLNL procurement vehicle in FY92/93**
- 2. Deploy DS-3 SMDS attachments at ARC, GSFC, JPL, LaRC & LeRC in FY93**
- 3. Deploy new routers with DS-3 SMDS support with FDDI ring(s) in FY93**
- 4. ARC and GSFC sites provide interface to T3 NSFnet connectivity via FIX-E and FIX-W**
- 5. Deploy 155 Mbps support in FY94 given budget and requirements**
- 6. Deploy 622 Mbps support in FY95 given budget and requirements**
- 7. Prototype SMDS technology for use in other NASA and Federal programs as a production oriented network service**

NASA: Issues & Concerns

REMOTE INVESTIGATOR ACCESS

- Assumes investigators are located at well-connected sites
- Future of NSFnet backbone still being defined
- Regionals vary in quality and service (little accountability!)

HIGH PERFORMANCE PACKET SYSTEM

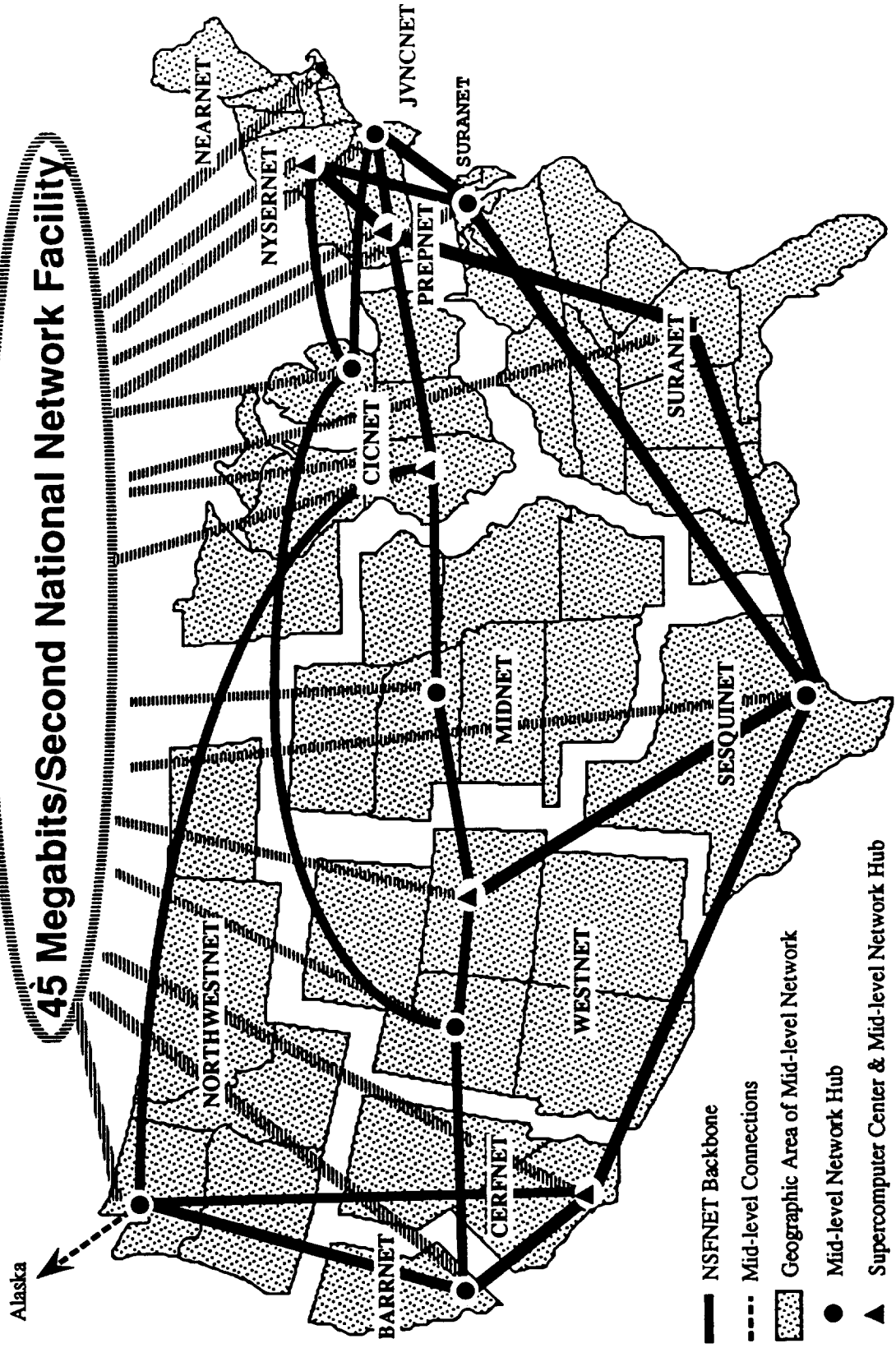
- Vendor support is immature for routers, DSU's, switches
- Lack of Inter-Carrier-Interchange (ICI) protocol support
- IXC deployment of SONET proceeding at lackluster pace
- 155 Mbps and above to NASA sites is critically dependent on LEC SONET deployment
- Dependent on Telco support and deployment schedules
- Routing complexities when interconnecting VPN's over SMDS

NASA's NREN: SUMMARY

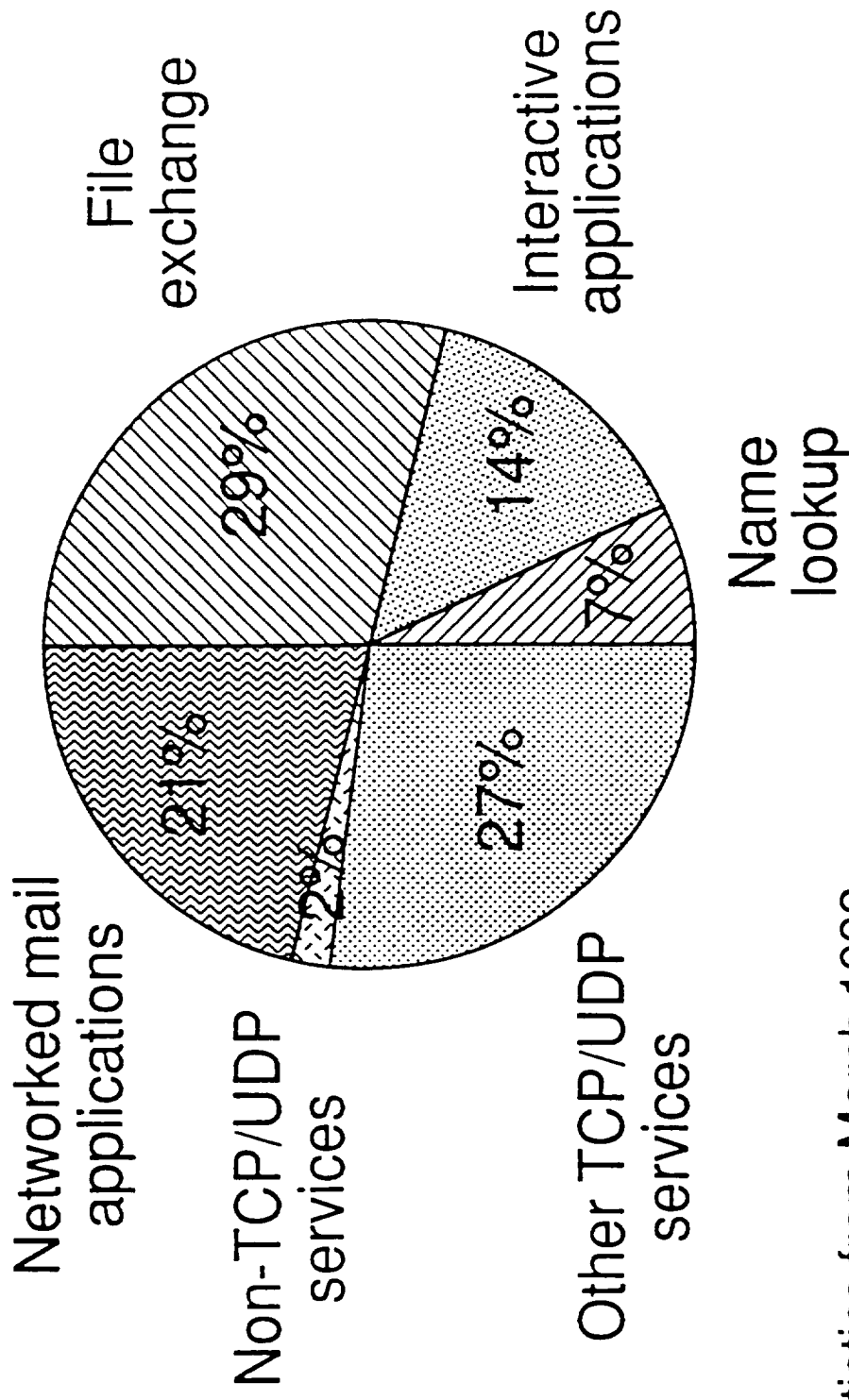
- **Focus on meeting NASA HPCC Grand Challenge requirements**
- **Maximizes use of existing network resources, NASA & non-NASA**
- **Strongly leverages on telecommunications carrier plans and investments: no private dedicated systems**
- **Minimizes NASA costs while still providing high performance capabilities**
- **Fully consistent with national program objective to construct a high performance national network infrastructure**
- **Provides for strong technology transfer to other programs**
- **Provides testbed for advanced routing and management designs for large scale public data networks**

NSFNET

(Including Upgrade)



Major NSFNET Applications By Packets

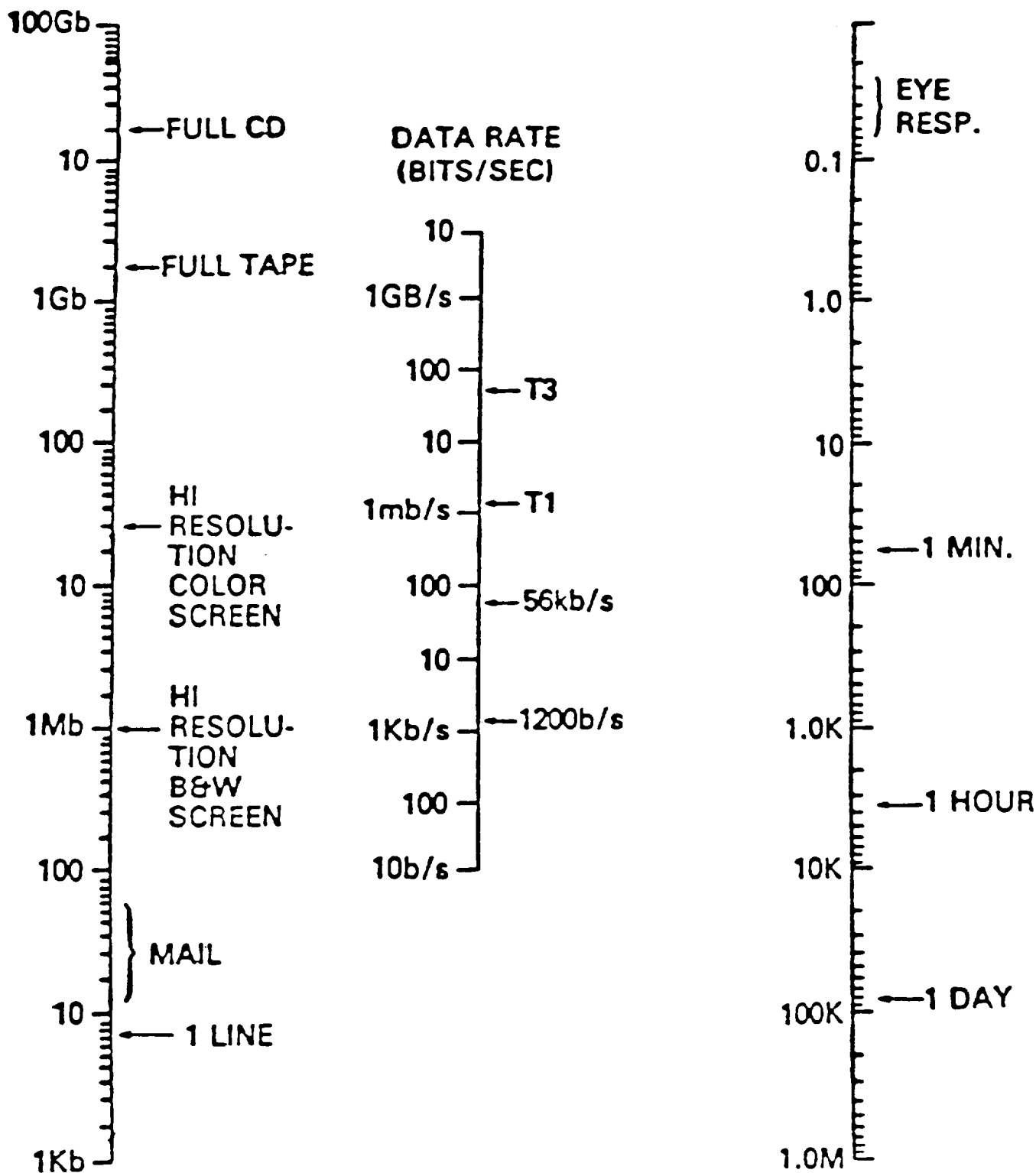


Statistics from March 1992

Merit

SIZE: SINGLE
TRANSMISSION (BITS)

TRANSMISSION
TIME (SEC.)



DATA TRANSMISSION NOMOGRAM



NREN EVOLUTION

Stage 3

Gbits/sec

NREN

Stage 3 Operational Network

Stage 3 Testbeds/Experimental Networks

Stage 3 Research and Development

Transition to
Commercial
service

Stage 2

45Mbits/sec

NREN

Stage 2 Operational Networks

Stage 1

1.5 Mbits/sec

Internet

Stage 1 Operational Networks

Stage 1 & 2 Development

89 90 91 92 93 94 95 96



HPCC BUDGET REQUEST FY92

	Base FY 91	HPCC FY 92	HPCS	ASTA	NREN	BRHR
DARPA	183.0	232.2	103.3	38.5	32.9	57.5
DOE	65.0	93.0	15.0	58.0	12.0	8.0
NASA	54.0	72.4	14.2	49.8	7.4	1.0
NSF	169.0	213.0	24.0	103.0	32.7	53.3
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TOTAL	489.4	638.3	156.8	265.1	91.9	124.5



Interagency Interim NREN and the HPCC

- **NREN is a Multi-Agency Component of the HPCC**
- **U. S. Executive (Little Blue Book) and Legislative
(PL 102 - 194) support**
- **NREN has 2 Components**
 - 1) IINREN (NSF - lead coordinating role)**
 - 2) Gigabit Research (DARPA - lead role)**